

# New materials of Cervidae (Artiodactyla, Mammalia) from Tuchengzi of Huade, Nei Mongol, North China

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**Abstract** Five taxa of Cervidae were identified from the new collection at Tuchengzi locality in Huade, Nei Mongol: *Eostyloceros blainvillei*, *E. triangularis*, *Euprox* sp., *Cervavitus huadeensis* and *C. shanxius*, among which the first three taxa were discovered for the first time in Huade area, and the dental specimens of the last two taxa from Tuchengzi locality are also described for the first time. *E. blainvillei* is a large muntiacine, diagnosed by long, thick and medially curved main beam and a relatively long brow tine emerging directly from the burr. It was originally found in Yushe Basin in Shanxi Province, and reported later from Qaidam Basin in Qinghai Province. Huade is the third area yielding the species. *E. triangularis* distinguishes from *E. blainvillei* by its special main beam with triangular cross sections, and it was reported only from Yushe Basin. Its presence in Huade extended its geographic distribution northward to Nei Mongol. *Euprox* is a transitional form of cervids from permanent antlers to seasonally deciduous ones and it is found in several localities across Eurasia. Huade is the third area in Nei Mongol yielding the taxon after Tung Gur and Siziwang Qi (Siziwang Banner). *C. huadeensis* is a pliocervine with four tines, and particularly with two distal tines sword-like. It is found at Tuchengzi for the second time, but not elsewhere so far, and it seems to be an endemic taxon. *C. shanxius* distinguishes from *C. novorossiae* by absence of *Palaeomeryx* fold on lower molars. It is widely found in Shanxi, Shaanxi, Gansu and Nei Mongol of northern China. It is often found with numerous specimens in a locality that indicates it lived in large herds. *E. blainvillei*, *E. triangularis* and *C. shanxius* are main members of Yushe I, i.e. Mahui Formation or Baodean. *Euprox* appeared also mainly in the Late Miocene. The geological age of Tuchengzi locality based on excavated cervids is therefore the Late Miocene. The numerous specimens of *C. shanxius* indicates forested environment in Huade area in that age.

**Keywords** Tuchengzi, Huade, Nei Mongol; Late Miocene; Cervidae

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## 1 Introduction

Huade is a northeastern county of Ulanqab Municipality in central Nei Mongol, North China. The downtown of Huade is about 299 km northwest (headings: 318.66°) of Beijing City. The expedition by Swedish geologist and paleontologist Johan Gunna Andersson and his Chinese collaborators in 1919 marked the first paleontological investigation in Huade area, and two fossil localities, Ertemte and Harr Obo were discovered and excavated in 1919 and 1920 (Andersson, 1923). A Sino-Soviet joint expedition team carried out a second paleontological investigation in Huade area in 1959 and discovered and collected many large mammal fossils from two new fossil localities, Tuchengzi and Heishatu in the county (Zhai, 1963; Qiu, 1979). Tuchengzi locality is about 1 km north of Tuchengzi Village and about 700 m southeast of Dawan Village, and about 20 km southeast (heading: 335°) of Huade downtown. It belongs administratively to Tuchengzi Village although it is physically closer to Dawan than to Tuchengzi. Some follow-up excavations for “dragon bones” by local habitants were carried out in the 1980s at Tuchengzi locality, and the fossils were sold to a Chinese medicine store at Huade downtown. An incomplete mandible of a probable pliopithecine was later recovered from the store. In order to find more primate specimens and justify biostratigraphic status of Tuchengzi locality, a series of excavations have been conducted since 2013 (Dong, 2014; Dong et al., 2014, 2016). The cervids are the most common materials collected during the excavations, and here we describe new materials of five taxon of Cervidae from Tuchengzi locality. The dental terminology follows that by Dong (2004), upper teeth are abbreviated in upper case and the lower ones in lower case. The specimens described are housed at the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (IVPP).

## 2 Systematic paleontology

**Mammalia Linnaeus, 1758**

**Artiodactyla Owen, 1848**

**Ruminantia Scopoli, 1777**

**Pecora Flower, 1883**

**Cervoidea Simpson, 1931**

**Cervidae Gray, 1821**

**Muntiacinae Pocock, 1923 (= Cervulinae Sclater, 1870)**

***Eostyloceros* Zdansky, 1925**

***Eostyloceros blainvillei* Zdansky, 1925**

(Fig. 1A, C)

1925 *Eostyloceros Blainvillei* gen. et sp. nov., Zdansky, p. 3

1927 *Eostyloceros Blainvillei*, Zdansky, p. 5

1937 *Eostyloceros blainvillei*, Teilhard de Chardin and Trassaert, p. 12

1937 ?*Eostyloceros* sp., Bohlin, p. 20-24

1979 *Eostyloceros blainvillei*, Wang and Wu, p. 539

**Material** A distal fragment of right main beam (IVPP V 23521.1), a small fragment of main beam (V 23521.11).

**Description** The distal fragment of main beam or main tine (V 23521.1), is cylindrical and curved inwards (Fig. 1A). The beam cross sections are oval. The maximal and minimal diameters at the broken end of the beam of V 23521.1 measure 34.1 and 20.8 mm respectively, with nearly 13 mm's difference and that the proximal cross section is somewhat flattened. The direct length from the tip to the broken end of the beam measures 160.1 mm and the curved length from the tip along lateral margin to the broken end is 212 mm. The surface of the beam is ornamented with longitudinal crests and furrows. The maximal and minimal diameters at the proximal broken end of the beam of V 23521.11 measure 27.1 and 21.9 mm respectively, and those at the distal broken end 18.2 and 14.3 mm respectively. The direct and curved lengths of the preserved beam measure 100.6 and 112 mm respectively. The cross sections of the beam are oval. The surface of the beam is also ornamented with longitudinal crests and furrows.

**Comparison and determination** The specimens are very close both morphologically and metrically to the type of *Eostyloceros blainvillei* from Wuxiang in Shanxi Province described by Zdansky (1925), e.g. cylindrical and curved main beam and oval beam cross sections. They are also close to those from Shenjiagou of Yushe Basin in Shanxi Province described by Teilhard de Chardin and Trassaert (1937), especially to the specimen THP10.217 (see comparison between C and E in Fig. 1). The right fragment V 23521.1 is closer than the short fragment V 23521.11 to the type of *E. blainvillei*. The specimens can therefore be included into *E. blainvillei*. The specimens from Qaidam Basin described by Bohlin (1937) are fragmental and there are no counterparts to be compared with Tuchengzi materials. The

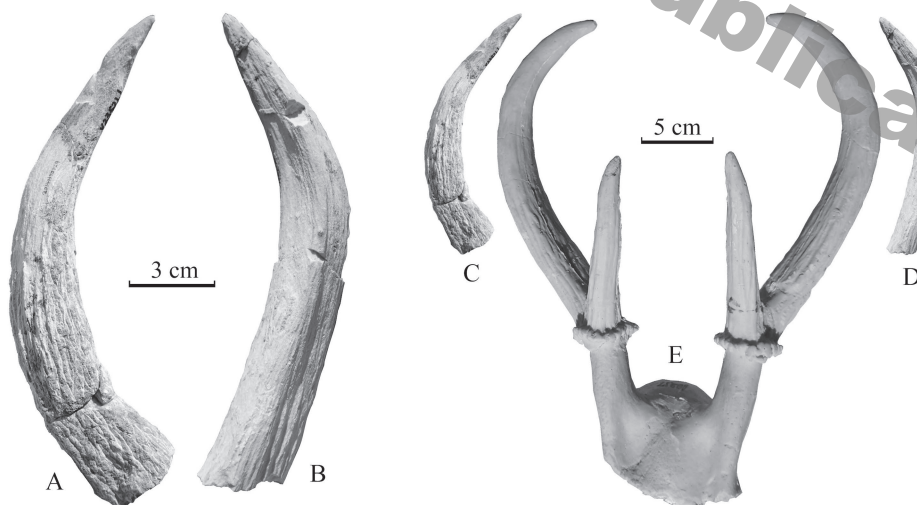


Fig. 1 Antler fragments of *Eostyloceros* from Tuchengzi and comparison with that from Yushe  
 A. anterior view of distal fragment of right main beam (IVPP V 23521.1) of *E. blainvillei*; B. anterior view of distal fragment of left main beam (V 23521.2) of *E. triangularis*; C. comparison of *E. blainvillei* from Tuchengzi (V 23521.1) with that (cast of THP10.217) from Yushe (E); D. comparison of *E. triangularis* from Tuchengzi (V 23521.2) with *E. blainvillei* (cast of THP10.217) from Yushe (E)

described specimens are also metrically similar to that of *Eostyloceros triangularis* from Wuxiang of Yushe Basin (Zdansky, 1925; Wang and Wu, 1979), while the cross sections of the main beam are oval in the described specimens but triangular in that of *E. triangularis*.

***Eostyloceros triangularis* Zdansky, 1925**

(Fig. 1B)

1925 ?*Eostyloceros triangularis* sp. nov., Zdansky, p. 6

1927 ?*Eostyloceros triangularis*, Zdansky, p. 5

1979 *Eostyloceros triangularis*, Wang and Wu, p. 539

**Material** A distal fragment of left main beam (IVPP V 23521.2).

**Description** The available specimen is a distal fragment of main beam or main tine, cylindrical and curved inwards (Fig. 1B). The beam cross sections are triangular. The maximal and minimal diameters at the broken end of the beam of V 23521.2 measure 28.1 and 25.2 mm, with only 3 mm's difference. The direct and curved lengths from the tip to the broken end of the beam measure 165.3 and 187 mm respectively. The surface of the beam is ornamented with longitudinal crests and furrows. In addition, the anterior side of the distal part of the beam forms a developed longitudinal ridge in V 23521.2 that makes the cross sections of the beam triangular.

**Comparison and determination** The specimen is metrically close to the type of *Eostyloceros blainvillei* from Wuxiang in Shanxi Province described by Zdansky (1925, 1927) and those from Shenjiagou of Yushe Basin in Shanxi Province described by Teilhard de Chardin and Trassaert (1937). But the beam cross sections of the described specimen are triangular and in accordance with the diagnosis of *Eostyloceros triangularis* (Zdansky, 1925; Wang and Wu, 1979). In addition, the distal part of the beam curves more distally in V 23521.2 than in V 23521.1 (see Fig. 1A, B). The differences between V 23521.2 and V 23521.1 are evident and the former is regarded as of *E. triangularis*.

***Euprox* Stehlin, 1928**

***Euprox* sp.**

(Fig. 2F)

**Material** A proximal antler fragment with pedicle (IVPP V 23517.2).

**Description** The specimen V 23517.2 is a proximal antler fragment with pedicle and broken brow tine and main beam (Fig. 1F). The pedicle is intermediately long, with its medial length of 35.6 mm, maximal diameter of 31.2 mm and minimal one of 27.1 mm, its cross sections are oval. The burr is composed of a series of developed bony nodules, with maximal and minimal diameters of 51.4 and 46.1 mm respectively, its thickness is 8.4 mm. The antler base is relatively short, with maximal and minimal diameters of 47.3 and 34.1 mm respectively. The brow tine and the main beam simultaneously emerge directly from the burr, the maximal and minimal diameters above the bifurcation measure 29.7 and 24.5 mm respectively. The main beam, or second tine, is robust and straight, with maximal and minimal diameters of 38.8

and 27.2 mm respectively. The bifurcation angle between brow tine and main beam measures 56°. The surface of the antler is ornamented with developed longitudinal crests and furrows.

**Comparison and determination** The described specimen is morphologically close to A.M.26799 from Tung Gur Formation “about 25 miles northeast of Gur Tung Khara Usu” of Nei Mongol referred as *Euprox* sp. by Colbert (1936, 1940). But Tuchengzi specimen is evidently larger, e.g., the diameter cross both brow tine and main beam at its antler base is about 47 mm, and that in A.M.26799 is about 35 mm (measured from Colbert, 1936: fig. 9). Compared with *Euprox altus* from Damiao of Siziwang Qi (Siziwang Banner) (Wang and Zhang, 2011), Tuchengzi specimen is larger, its 46.1 mm’s minimal diameter of burr is evidently larger than 35.7 mm’s antero-posterior diameter of the largest specimen (IVPP V 17738.7) of *E. altus* from Damiao (Wang and Zhang, 2011: table 1). In addition, the bifurcation of Tuchengzi specimen is set lower than that of Damiao specimens. Compared with *Euprox robustus* from Yuanmou (Dong et al., 2003), the length of pedicle of Tuchengzi specimen (35.6 mm) is evidently shorter than that of Yuanmou specimen (64.2 mm, Dong et al., 2003: table 1). In addition, the bifurcation of Tuchengzi specimen is set higher than that of Yuanmou specimen. Tuchengzi specimen seems representing a new species based on its peculiar characters, but it is imprudent to name it with the present state of specimen preservation and by the absence of more complete materials.

#### **Pliocervinae Khomenko, 1913**

##### ***Cervavitus* Khomenko, 1913**

##### ***Cervavitus huadeensis* Qiu, 1979**

(Fig. 2A–C, 5G)

1979 *Cervocerus huadeensis* sp. nov., Qiu, p. 225

2011 *Cervavitus huadeensis*, Dong, p. 605

2014 *Cervavitus huadeensis*, Dong, p. 25

**Material** A left antler fragment with two broken tines (IVPP V 23517.5), a distal fragment of a third or fourth tine (V 23517.6), a left antler fragment with three broken tines (V 23517.7) and a left mandibular fragment with dp2-m2 (V 23522).

**Description** The specimen V 23517.5 is a middle section of a broken antler (Fig. 2A), and the two remaining broken tines are probably the second and third tines. The presumed third tine (the left one in Fig. 2A) probably bifurcated again but the fork was broken off before being discovered. The maximal and minimal diameters at the proximal broken section of the specimen measure 28.4 and 24.8 mm respectively. The maximal and minimal diameters at the distal broken section of the presumed second tine measure 28.7 and 20.6 mm respectively, and those of the presumed third tine 30 mm above the bifurcation 22.1 and 16.2 mm respectively. The length from the proximal broken end to the center of bifurcation measures 90 mm. The lengths from the center of bifurcation to the distal ends of the presumed second and third tines measure 55 and 130 mm respectively. The main beam curves slightly inward. The angle of bifurcation is about 55°. The surface of the antler is ornamented with longitudinal crests and furrows.

The specimen V 23517.6 is a distal fragment of a third or fourth tine (Fig. 2B). The tine is sword-like and flattened in the intermediate part. The maximal and minimal diameters at the proximal broken section of the specimen measure 30.7 and 27.2 mm respectively, and those in the middle of the fragment 33.2 and 20.7 mm respectively, the length of the preserved tine 226 mm. The surface of the antler is also ornamented with longitudinal crests and furrows.

The specimen V 23517.7 is also a middle section of a broken antler (Fig. 2C). Its first tine is broken off just at the first bifurcation, the second tine is broken off at 6 mm above the second bifurcation. The main beam is moderately flattened above the first bifurcation and broken off 68 mm above the second bifurcation and it seems having tendency to bifurcate a fourth tine. The maximal and minimal diameters in the middle of the main beam measure 24.4 and 21.6 mm respectively, and those in the middle of the distal beam measure 36.1 and 26.3 mm respectively. The main beam curves slightly inward. The cross section just above the first bifurcation is somehow triangular, but it becomes laterally elongated in most part of the main beam. The angle of the second bifurcation is about 65°. The surface of the antler is also ornamented with longitudinal crests and furrows.

The mandibular fragment with dp2-m2 (V 23522) (Fig. 5G) is evidently larger than those of *C. shanxius* uncovered from the same locality (Fig. 5A-F). It is the only material of *C. huadeensis* with teeth so far found from Tuchengzi. The dp2 is morphologically simple and composed of a main cusp and some minor cusps. The trigonid basin, entoflexid and talonid basin are worn and not evident. Its length, width and height measure 9.4, 5.1 and 6.4 mm respectively. The dp3 is composed of two main cusps and some minor cusps. Trigonid basin is evident and opened lingually, the other valleys are not evident. Its length, width and height measure 14.3, 7.52 and 7.4 mm respectively. The dp4 is composed of three lobes of typical cervid type. Its length and width measure 21.98 and 10.0 mm respectively. The length of dp2-dp4 measures 45.34 mm. The m1 is composed of four main cusps and the worn surfaces of protoconid and hypoconid are rather triangular. The *Palaeomeryx* fold is clearly absent, the precingulum either, but ectostylid is present although not developed. The length, width and height of m1 measure 19.42, 11.2 and 15.3 mm respectively. The m2 morphologically resembles the m1 but the ectostylid is absent. Its length, width and height measure 23.78, 13.6 and 16.7 mm respectively. The height and width of the mandibular cross section at m1 measure 29.7 and 20.6 mm respectively.

**Comparison and determination** The specimens are very close to those of *C. huadeensis* from Tuchengzi locality (Qiu, 1979), e.g. flattened and moderately curved main beam; the sword-like third or fourth tine; the cross sections of the main beam just above the first bifurcation is somehow triangular; the angle of the first bifurcation is about 50–55°, and that of the second is about 60–75°; the length between the first and second bifurcations is about 135–150 mm, etc. The specimens are also close to those of *Cervavitus shanxius* from Yushe Basin (Teilhard de Chardin and Trassaert, 1937), e.g. moderate bifurcation angle within 50–80°, main beam moderately curved. But the flattened main beam and sword-like third or

fourth tine distinguish Tuchengzi specimens from *C. shanxius* and other *Cervavitus*. The key character of *C. huadeensis* that differs from *C. shanxius* is that the former has the fourth tine, and is evidently larger than the latter (Qiu, 1979). The described specimens are more related to *C. huadeensis* from the same locality.

The mandibular fragment with dp2-m2 (V 23522) is morphologically similar to those of *C. shanxius*, but metrically larger than those of *C. shanxius* from the same locality (Fig. 5). This dimensional difference in teeth is similar to that in antlers between *C. huadeensis* and *C. shanxius*.



Fig. 2 Antler fragments of Cervidae from Tuchengzi locality

A–C. anterior view of *Cervavitus huadeensis*: A. an antler fragment (IVPP V 23517.5), B. a third or fourth tine (V 23517.6), C. an antler fragment (V 23517.7); D–E. *C. shanxius*: D. a distal fragment of antler (V 23517.4), E. a left proximal antler fragment with pedicle and partial frontal (V 23517.1); F. *Euprox* sp.: a proximal antler fragment with pedicle (V 23517.2)

### *Cervavitus shanxius* Dong & Hu, 1994

(Fig. 2D–E, 3–4, 5A–F, 6–7; Tables 1–3)

1925 *Cervoceros novorossiae*, Zdansky, p. 12–24

1927 *Cervoceros novorossiae*, Zdansky, p. 6

1937 *Cervoceros novorossiae*, Teilhard de Chardin and Trassaert, p. 30–38

1979 *Cervoceros novorossiae*, Qiu, p. 226

1994 *Cervavitus novorossiae shanxius* subsp. nov., Dong and Hu, p. 214–217

2007 *Cervavitus shanxius*, Petronio et al., p. 124

2011 *Cervavitus shanxius*, Dong, p. 605

2014 *Cervavitus shanxius*, Dong, p. 25

**Material** A distal fragment of antler with two tines (IVPP V 23517.4); a left proximal antler fragment with pedicle and partial frontal (V 23517.1); a left maxillary canine (V

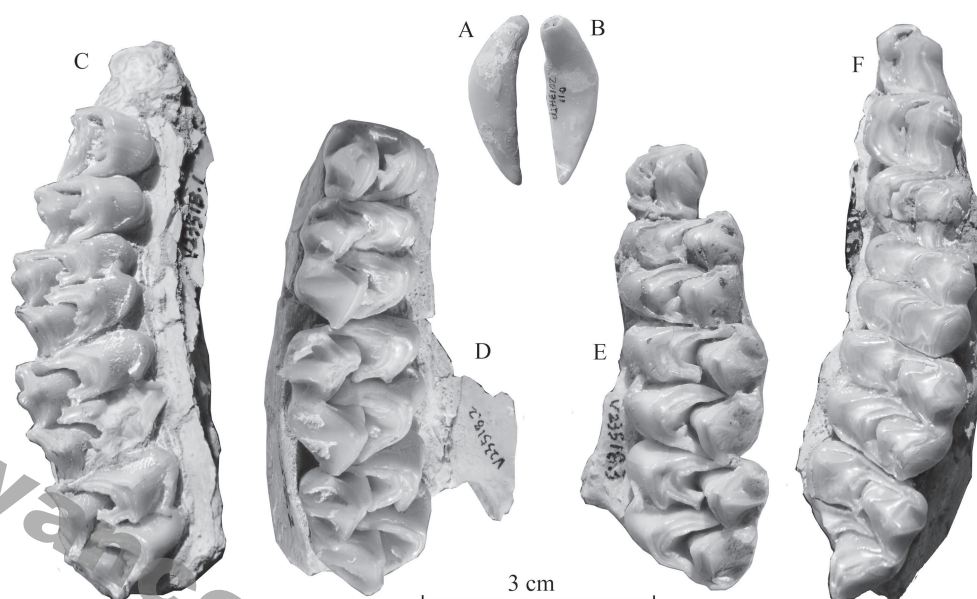


Fig. 3 Upper teeth of *Cervavitus shanxiensis* from Tuchengzi locality

A–B. a left maxillary canine (IVPP V 23518.11): A. labial view, B. lingual view;  
C–F. occlusal view of maxillary fragments: C. right P3–M3 (V 23518.1), D. right P4–M3 (V 23518.2),  
E. left P4–M3 (V 23518.3), F. left P2–M3 (V 23518.8)

23518.11); a right maxillary fragment with P3–M3 (V 23518.1); a right maxillary fragment with P4–M3 (V 23518.2); a left maxillary fragment with P4–M3 (V 23518.3); a left maxillary fragment with P2–M3 (V 23518.8); a left i1 (V 23519.22); two right i1 (V 23519.23/25); a right i3 (V 23519.24); two right mandibular fragments with p2–m3 (V 23519.1/3); a left mandibular fragment with broken p2 and complete p3–m3 (V 23519.2); a right mandibular fragment with dp2–m1 (V 23519.18); a left mandibular fragment with complete p2–m2 and broken m3 (V 23519.4); a left mandibular fragment with dp2–m2 (V 23519.13); a proximal middle phalange (V 23520.1); an intermediate middle phalange (V 23520.2); three distal middle phalanges (V 23520.3–5); some very fragmental upper and lower dentitions with permanent or deciduous cheek teeth.

**Description** The specimen V 23517.1 is a left proximal antler fragment with pedicle and partial frontal (Fig. 2E). It is of a young individual based on its slender pedicle. The pedicle is relatively long, with its medial length of 45.5 mm, maximal diameter of 27.8 mm and minimal one of 26.6 mm, its cross section is oval. The pedicle prolonged by a mild ridge on the frontal. The burr is composed of a series of small bony nodules, with maximal and minimal diameters of 37.8 and 36.1 mm respectively, its thickness is 7.6 mm. The main beam is thin and broken at 112 mm above the burr. There is a bony nodule about 19 mm right above the burr, evidently an emerging brow tine and indicating the antler is from a juvenile individual. There is a mild ridge above the nodule on the main beam. The maximal and minimal diameters of the main beam 55 mm above the burr measure 26.2 and 22.9 mm respectively. The surface of the antler

is ornamented with mild longitudinal crests and furrows.

The specimen V 23517.4 is a distal fragment of antler with distal part of broken main beam (terminal tine) and complete branching tine (Fig. 2D), the maximal and minimal diameters at the proximal broken section measure 22.3 and 18.2 mm respectively, those of the main beam just above the bifurcation measure 20.8 and 14.1 mm respectively, and those of the tine above the bifurcation 20.9 and 13.2 mm respectively. The distance from the center of bifurcation to the proximal broken section of main beam is 116 mm, that to distal broken section of the beam about 97 mm, and that to the tip of the tine 142 mm. The angle of bifurcation is 65°. The surface of the antler is ornamented with mild longitudinal crests and furrows.

The maxillary canine (V 23518.11) is crescent in both labial and lingual views (Fig. 3A–B), the tooth crown curves medially with rounded mesial edge and sharp distal edge. The mesial-distal diameter of the crown base is 8.78 mm and the labial-lingual diameter is 4.82 mm, the crown height is 17.4 mm, the total height with both crown and root is 26.7 mm.

Besides an upper canine, maxillary dentition includes six cheek teeth on each side. The measurements of upper cheek teeth are listed in Table 1.

The P2 is composed of four simple main cusps in two overlapping lobes (Fig. 3F), the

**Table 1** Measurements of upper cheek teeth of *Cervavitus shanxius* from Tuchengzi locality (mm)

	Number	Minimum	Average	Maximum	Standard Deviation
P2 L	3	13.62	14.18	15	0.726
P2 W	3	10.1	11.17	11.9	0.945
P2 H	3	7.5	8.97	11.1	1.887
P3 L	4	12.02	13.02	14.38	1.087
P3 W	4	10.9	12.80	13.92	1.355
P3 H	4	8.6	10.04	13.64	2.409
P4 L	7	9.9	10.69	12.6	0.902
P4 W	6	13.52	14.35	15.12	0.520
P4 H	7	8.5	10.43	13.5	1.749
P2-4 L	2	37	37.40	37.8	0.566
M1 L	11	14.22	15.39	17.5	0.921
M1 W	11	14.38	16.54	17.8	1.014
M1 H	11	5.54	10.47	13.8	2.725
M2 L	11	16.4	17.12	18.9	0.854
M2 W	11	17.5	19.23	20.8	0.866
M2 H	11	7.9	12.00	14.5	2.228
M3 L	10	15.74	16.71	17.48	0.571
M3 W	10	15.8	18.06	19.56	1.120
M3 H	10	8.8	11.93	14.1	1.587
M1-3 L	9	45.4	47.68	50.5	1.563
P2-M3 L	1	82	82.00	82	
DP2 W	1	10.2	10.20	10.2	
DP3 L	2	12.3	13.50	14.7	1.697
DP3 W	2	12.1	13.75	15.4	2.333
DP4 L	2	6.18	9.76	13.34	5.063
DP4 W	2	5.72	9.60	13.48	5.487

Note: L. length; W. width; H. height.

anterior main cusps have tendency to fuse with posterior cusps, but entoflexus is present. The P3 is wider than P2 and composed of three or four simple main cusps (Fig. 3C, F), its entoflexus is weak. The P4 is composed of two main cusps with medial crista (Fig. 3C–F).

The maxillary molars are morphologically similar to each other and characterized by developed entocingulum and the presence of neocrista which is evident on M1, developed on M2 and very developed on M3 (Fig. 3C–F).

The mandibular dentition includes three lower incisors and six cheek teeth on each side, but the i2 is not available in the studied materials. The measurements of lower teeth are listed in Table 2.

The i1 has an axe-like crown and with slightly curved cylindrical long root (Fig. 4A–F). The top of the crown is a sharp blade, the labial surface of the crown is convex and the lingual surface is concave. A lingual cingulum is developed on the lingual side of crown base. The i3 is dagger-like (Fig. 4G–H), the crown is mesiodistally narrow and labial-lingually thin, the labial surface of the crown is convex and the lingual surface is concave, the root is curved and cylindrical.

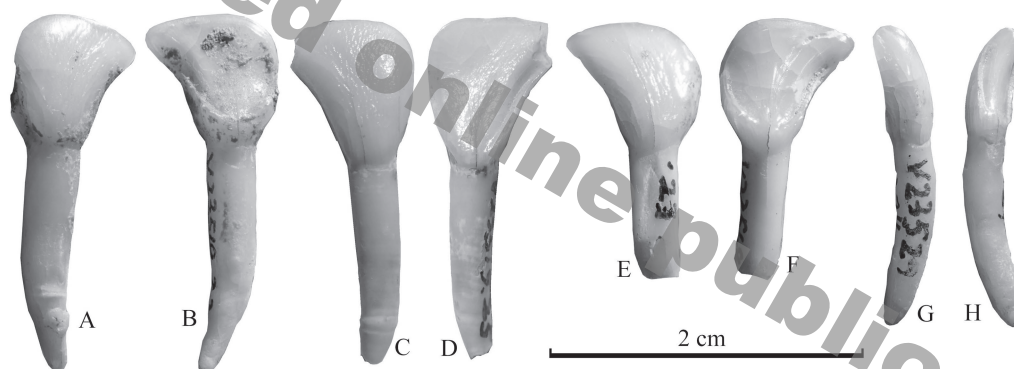


Fig. 4 Lower incisors of *Cervavitus shanxiensis* from Tuchengzi locality

A–B. a left mandibular i1 (IVPP V 23519.22); C–D. a right i1 (V 23519.25); E–F. a right i1 (V 23519.23);

G–H. a right i3 (V 23519.24); A, C, E, G. labial views, B, D, F, H. lingual views

The p2 is morphologically simple in lower premolars and composed of a main cusp and some minor cusps (Fig. 5A, C–D). The trigonid basin, entoflexid and talonid basin are present and opened lingually. The p3 is composed of two main cusps and some minor cusps (Fig. 5A–D). Paraflexid, trigonid basin, entoflexid and talonid basin are all present and opened lingually, the hypoflexid is also present. The p4 is similar to p3, but evidently larger, and metaconid extends mesiodistally (Fig. 5A–D).

The m1 is composed of four selenodont main cusps, the *Palaeomeryx* fold is evidently absent, precingulum is present but not developed, and ectostylid is present but not developed (Fig. 5A–F). The m2 (Fig. 5A–E) morphology resembles the m1. The m3 is composed of three lobes, and the anterior two lobes resemble those of m1 and m2, but the third lobe is composed of a developed hypoconulid and a small entoconulid (Fig. 5A–C).

**Table 2** Measurements of lower teeth of *Cervavitus shanxius* from Tuchengzi locality (mm)

	Number	Minimum	Average	Maximum	Standard Deviation
i1 m-d	3	7.82	8.17	8.64	0.422
i1 l-l	3	4.72	4.75	4.82	0.058
i1 h	3	8.08	9.64	10.92	1.441
i3 m-d	1	3.32	3.32	3.32	
i3 l-l	1	3.28	3.28	3.28	
i3 h	1	9.02	9.02	9.02	
p2 L	5	7.74	9.99	11.8	1.524
p2 W	5	4.5	5.30	5.7	0.469
p2 H	4	5.1	6.15	7.1	0.881
p3 L	7	11.6	12.66	14.8	1.066
p3 W	8	5.8	6.74	7.7	0.637
p3 H	8	5.62	6.83	9.1	1.095
p4 L	10	8.12	12.91	14.52	1.779
p4 W	10	6.88	8.08	8.8	0.618
p4 H	9	5.12	7.56	11.38	2.201
p2-4 L	5	32.5	34.86	38.1	2.066
m1 L	20	12.56	14.60	16.7	1.110
m1 W	20	9.38	10.07	10.8	0.421
m1 H	16	3.4	8.00	11.4	2.558
m2 L	15	15.1	16.97	18.7	0.863
m2 W	15	10.78	11.73	12.36	0.395
m2 H	14	4.9	9.87	15	3.203
m3 L	5	13.3	20.52	22.9	4.144
m3 W	8	11.12	11.39	11.78	0.225
m3 H	6	5.68	10.11	13.42	2.906
m1-3 L	5	48.4	52.30	56.1	3.225
p2-m3 L	4	77.9	86.00	90.4	5.714
dp2 L	4	8.26	8.99	9.72	0.616
dp2 W	4	3.96	4.39	5.18	0.571
dp3 L	5	11.58	12.65	13.42	0.797
dp3 W	5	5.72	5.96	6.42	0.282
dp4 L	8	17.36	18.57	19.6	0.798
dp4 W	8	8.1	8.28	8.52	0.144
dp2-4 L	4	36.28	38.88	40.7	2.071
mc@m1 H	9	19.02	22.31	25	2.124
mc@m1 W	9	11.66	13.04	14.3	0.959

Note: L. length; W. width; H. height; m-d. mesiodistal diameter; l-l. labial-lingual diameter; mc@m1. mandibular cross section at m1.

Three lower deciduous premolars are very different from each other (Fig. 5E–F). The dp2 is morphologically simple and composed of a main cusp and some minor cusps. The trigonid basin, entoflexid and talonid basin are present and opened lingually. The dp3 is morphologically complex with all essential components present. The dp4 is completely molarized and composed of three lobes, with anterior lobe the smallest and the posterior one the largest.

Five limb bones are recognized as of *Cervavitus shanxius*, a proximal middle phalange (V 23520.1), an intermediate middle phalange (V 23520.2) and three distal middle phalanges (V 23520.3–5). The proximal, intermediate and distal phalanges can match well with each other and

they are considered as from the same species. Their measurements are listed in Table 3. They are recognized as of *C. shanxius* because their dimensions are proportional to those of antlers and teeth of *C. shanxius* on one hand, and the specimens of antlers and teeth of *C. shanxius* are much more numerous than those of *C. huadeensis* from the same locality on the other.

**Comparison and determination** The distal fragment of antler (V 23517.4) is close to that of the type of *Cervavitus shanxius* (THP14.267, Teilhard de Chardin and Trassaert, 1937: pl. IV, fig. 2; Dong and Hu, 1994), e.g. the second and third tines curve slightly medially, the ornamentation of longitudinal crests and furrows are smooth. The left proximal antler fragment

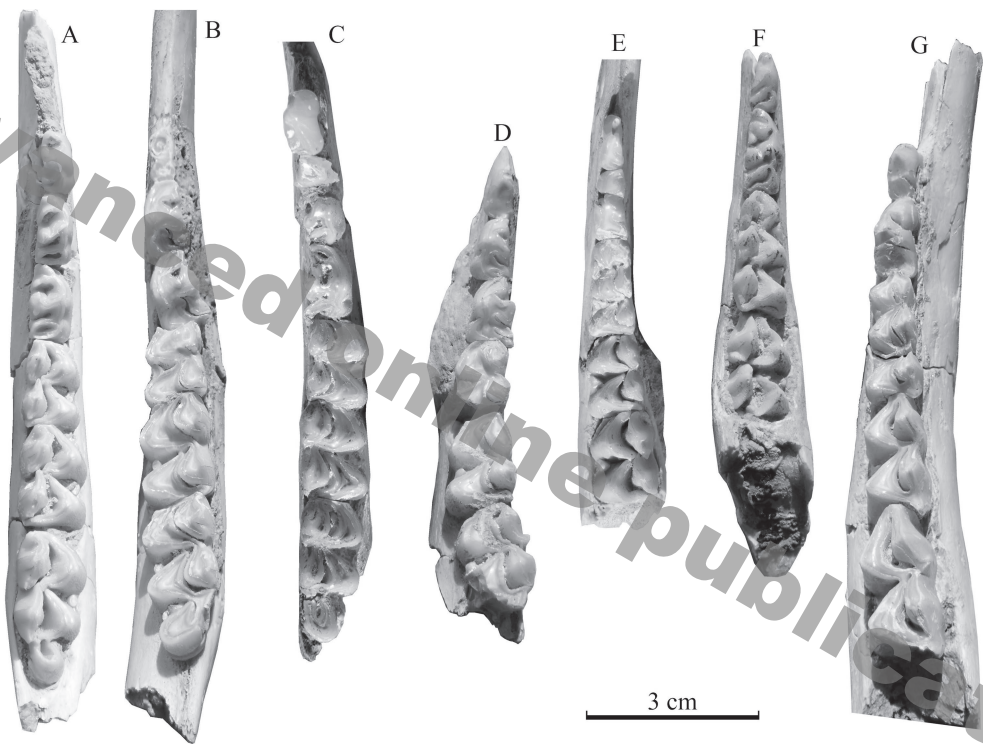


Fig. 5 Occlusal view of lower cheek teeth of *Cervavitus* from Tuchengzi locality

A–F. *C. shanxius*: A., C. two right mandibular fragments with p2–m3 (IVPP V 23519.1/3), B. a left mandibular fragment with broken p2 and complete p3–m3 (V 23519.2), D. a left mandibular fragment with complete p2–m2 and broken m3 (V 23519.4), E. a left mandibular fragment with dp2–m2 (V 23519.13), F. a right mandibular fragment with dp2–m1 (V 23519.18); G. *C. huadeensis*: a left mandibular fragment with dp2–m2 (V 23522)

Table 3 Measurements of limb bones of <i>Cervavitus shanxius</i> from Tuchengzi locality (mm)						
IVPP		PAPD	PTD	Length	DAPD	DTD
V 23520.1	proximal middle phalange	19.98	16.16	45.22	12.5	13.34
V 23520.2	intermediate middle phalange	17.26	12.86	26.54	15.94	10.8
V 23520.3	distal middle phalange	19.8	11.82	29.1		
V 23520.4	distal middle phalange	18.88	13.1	33.94		
V 23520.5	distal middle phalange	17.4	11.1	30.02		

Abbreviations: PAPD. proximal anteroposterior diameter; PTD. proximal transversal diameter; DAPD. distal anteroposterior diameter; DTD. distal transversal diameter.

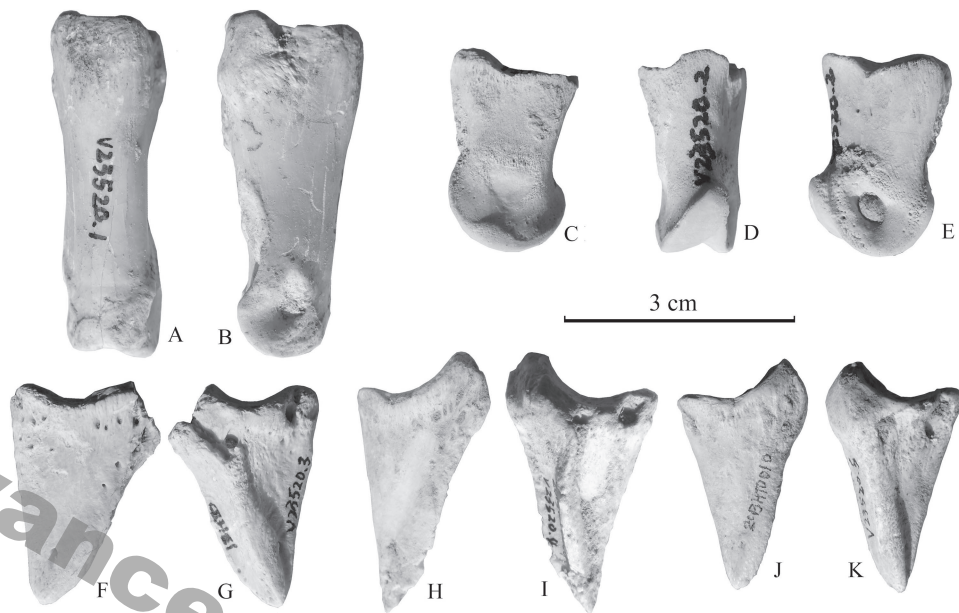


Fig. 6. Phalanges of *Cervavitus shanxius* from Tuchengzi locality

A–B. a proximal middle phalange (IVPP V 23520.1); C–E. an intermediate middle phalange (V 23520.2); F–K. three distal middle phalanges, (V 23520.3–5); A, D. anterior view; B, C, G, I, K. medial view; E. lateral view; F, H, J. anterior-lateral view

with pedicle and partial frontal (V 23517.1) is close to the type by its pedicle prolonging on the frontal by a ridge, and its antler structure is also similar to that of the type although the specimen is from a young individual. Many broken antlers (V 5635) from Tuchengzi, the same locality as those described above, were regarded as nearly the same as those of *C. shanxius* (previously regarded as *Cervocerus novorossiae*) from Yushe Basin (Teilhard de Chardin and Trassaert, 1937) and included into “*Cervocerus novorossiae*” by Qiu (1979). Compared with the antlers (V 5635) from Tuchengzi collected in 1959, the dimensions of new material are slightly smaller, but general morphology of both old and new material is similar to each other and can be considered as the same species. The antlers (V 5635) were interpreted as young stage of *C. huadeensis* by Wang and Zhang (2014) according to the morphological variations of antlers. With the discovery of two dimensionally different tooth types of *Cervavitus* at Tuchengzi locality, it is more likely that the two species of *Cervavitus* are present at Tuchengzi locality. The teeth and phalanges of *C. shanxius* from Tuchengzi are described for the first time in this paper because neither teeth nor phalanges of *C. shanxius* were reported previously from Tuchengzi (Qiu, 1979). Both upper and lower cheek teeth are morphologically the same as those of *Cervavitus shanxius* from Hounao in Yushe Basin (Dong and Hu, 1994), e.g. developed neocrista on upper molars, absence of *Palaeomeryx* fold on lower molars. But the dimensions of teeth from Tuchengzi (Tables 1–2) are slightly larger than those from Hounao (Dong and Hu, 1994: tables 4–5). Fig. 7 illustrates the dimensional comparison of the upper

and lower middle cheek teeth, the most numerous ones among dental materials, between the specimens from Tuchengzi and Hounao. The counterparts overlap with each other and the dimensions of the specimens from Tuchengzi are slightly larger than those from Hounao.

Compared with *Cervavitus novorossiae* from Lantian (Wang and Zhang, 2014), Lantian antlers appear more slender, neocrista is less developed in Lantian upper molars, and trigonid basin opens more widely in Lantian p4, but *Palaeomeryx* fold is absent in both Tuchengzi and Lantian lower molars.

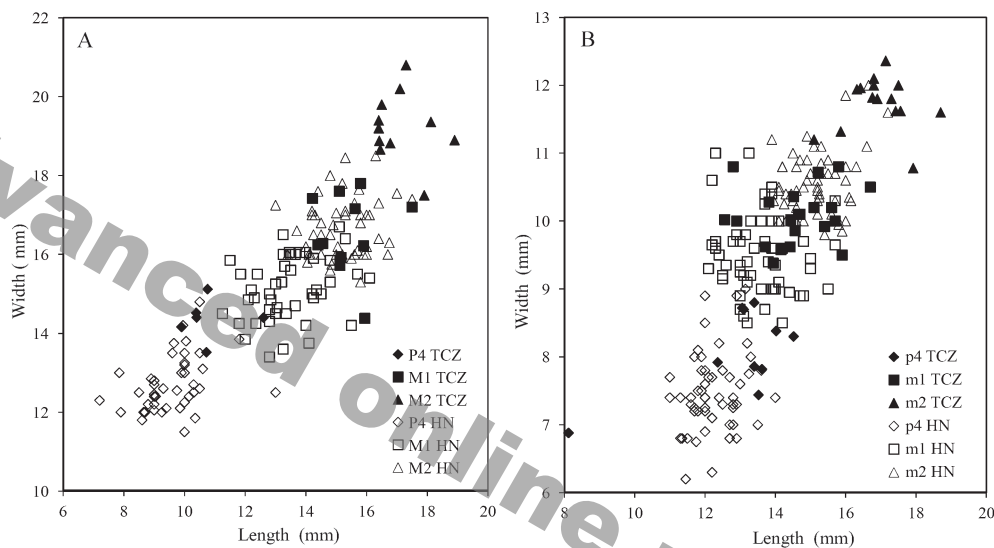


Fig. 7 Comparison of upper (A) and lower (B) middle cheek teeth of *Cervavitus shanxiensis* between Tuchengzi and Hounao specimens

Abbreviations: TCZ, Tuchengzi locality in Huade area; HN, Hounao locality in Yushe Basin

### 3 Discussion and conclusion

The muntiacine *Eostyloceros blainvillei* was established by Zdansky (1925) for the specimens from Wuxiang of Yushe Basin in Shanxi Province. There are at least four localities in Yushe Basin yielded the species: Loc. 73 (Tung-Tsun and Tou-Chiao-Kou) and Loc. 81 (Ho-Chien-Nao and Ho-Chien-Nao-Kou) in Wuxiang County (Zdansky, 1925), Loc. 77 (Hao-Chia-P'o) in Wuxiang County (Zdansky, 1927), Loc. 42 (Shenchiakou) in Yushe County (Teilhard de Chardin and Trassaert, 1937), and the best specimen is THP10.217 from Loc. 42 described by Teilhard de Chardin and Trassaert (1937) and housed in Tianjin Natural History Museum. The species was reported from Qaidam Basin, Qinghai Province, with some fragmental specimens (Bohlin, 1937; Wang and Wu, 1979). Huade becomes the third area yielding *E. blainvillei*, after Yushe Basin and Qaidam Basin. *Eostyloceros triangularis* was also established by Zdansky (1925) for the specimens from Loc. 81 in Wuxiang County and Loc. 77 in the same county (Zdansky, 1927). It is the first time that the species discovered outside Wuxiang. Other species of *Eostyloceros* found so far in China include *E. longchuanensis* from

Yuanmou in Yunnan Province (Lin et al., 1978) and *E. hezhengensis* from Hezheng in Gansu Province (Deng et al., 2014); and those abroad include *E. pidoplitschkoi* from southeastern Moldova and from the Lower Pliocene deposits of the Kuchurgan River at sites Novopetrovka, Yurievka, Voinich in the south of Ukraine, *E. propria* from the northeastern coast of the Lake Karabastuz in Kazakhstan, *E. actauensis* from the Middle Miocene of Dzhungarian Aktau in East Kazakhstan, and *E. maci* from the Pliocene of Olkhon Island in Lake Baikal (Vislobokova, 1990; Deng et al., 2014). The genus is thus distributed mostly in Asia and eastern Europe.

The antler of *Euprox* is a transitional form from permanent one to seasonally deciduous one by its developed burr, a structure connecting antler and pedicle and the location the antler sheds off the pedicle. *Euprox* was originally found in Europe (Stehlin, 1928; Thenius, 1948; Viret, 1961). It was first reported in China (Colbert, 1936, 1940) for the specimens from Tung Gur Formation in Nei Mongol. Vislobokova (1990) indicated the presence of the genus in the Qaidam Basin in the Late Miocene with a specimen which was originally described by Bohlin (1937) as *?Eostylaceros*. Zdansky's "*Dicrocerus cf. furcatus*" from the Late Miocene of Shanxi Province (Zdansky, 1925) was reassigned into *Euprox cf. E. furcatus* by Dong et al. (2003) for its developed burr. *Euprox robustus* from Leilao in Yuanmou Basin of Yunnan Province described by Dong et al. (2003) is the fourth form found in China. *E. grandis* establish by Hou (2015) for the material with long pedicle and weak burr from Linxia Basin is the fifth one in China. The *Euprox* sp. from Tuchengzi reconfirmed the presence of the genus in Nei Mongol. Other species of *Euprox* include *E. furcatus* from Austria (Stehlin, 1928; Thenius, 1948), *E. margaritae* from Russia (Vislobokova, 1990), and *E. sarmaticus* from Ukraine (Vislobokova, 2007), mostly from the Late Miocene.

*Cervavitus huadeensis* was established by Qiu (1979) for some peculiar antlers from Tuchengzi locality, e.g. antlers with four tines, main beam flattened and medially curved, brow tine located low on the main beam and with oval cross sections, the third and fourth tines sword-like. Both the antlers and teeth of *C. huadeensis* are dimensionally larger than those of *C. shanxius* from the same locality. It is an endemic species of Huade because it has not yet been found elsewhere. The new specimens reconfirmed the presence of such species in Huade area. During their revision on Eurasian pliocervines, Petronio et al. (2007) considered the remains referred to *C. huadeensis* by Qiu (1979) could be attributed to the species *Cervus (Sika) magnus* (= *Pseudaxis magnus* Zdansky, 1925) which is a rather common faunal element in many Chinese deposits of the Late Miocene and Early Pliocene. However, *Cervus (Sika) magnus* is in fact only found at Yidu County of Shandong Province and Dalian of Liaoning Province (Liu et al., 2017). The biostratigraphic range of *C. huadeensis* is recorded equivalent to MN12–MN13, but that of *C. (Sika) magnus* equivalent to MN16–MN17, there is a large gap between them. The cladistic analysis with the available characters shows that *C. huadeensis* falls in the cluster of *Cervavitus* to form a monophyly with *C. shanxius*, *C. ultimus*, *C. fenqii* and *C. novorossiae* (Dong, 2011). *C. huadeensis* is considered here as a pliocervine with the available specimens. It is true that *C. huadeensis* has some characters similar to cervine, e.g.

four tined antler, larger size, etc. Further determination requires more complete materials to acquire characters from upper dentition and skull.

*Cervavitus shanxius* is quite common in the Late Miocene of northern China, e.g. Yushe, Wuxiang, Jingle and Baode in Shanxi Province (Dong and Hu, 1994), Lushi in Henan Province (Wang and Wu, 1979), Huade in Nei Mongol (Qiu, 1979), and very likely in Lantian of Shaanxi Province (Zhang et al., 2002; Wang and Zhang, 2014) and Linxia Basin of Gansu Province (Deng, 2009). It was originally assigned to *Cervavitus* (= *Cervocerus*) *novorossiae* (Zdansky, 1925, 1927; Teilhard de Chardin and Trassaert, 1937; Qiu, 1979; Dong and Hu, 1994; etc.). Its absence of *Palaeomeryx* fold on lower molars distinguishes it from the *C. novorossiae* from type locality, Taraklia in Moldova (Khomenko, 1913), in which the fold is developed. Dong and Hu (1994) established a subspecies of *C. novorossiae shanxius* for such distinction. Petronio et al. (2007) considered such distinction was specific and upgrade the subspecies to species and the upgrade was accepted afterwards (e.g. Dong, 2011; Dong et al., 2014) although Wang and Zhang (2014) supposed the existence of Khomenko's *C. novorossiae* in Lantian and Baode. The character of developed neocrista on molars in *C. shanxius* is very peculiar, it is also present in *Cervavitus* sp. from Kohfidisch in Austria (Vislobokova, 2007), and it is probably the character of all Eurasian *Cervavitus*. *C. shanxius* is not only present in many localities in northern China, but also unearthed in relatively large quantity. It indicates that the species lived in large herds and widespread. Consequently the areas of its fossil localities should be well forested to feed such large herds of browsers.

Ertemte and Harr Obo of Huade investigated by Andersson (1923) were reinvestigated in 1980 by a Sino-German expedition team with a collection of large quantity of small mammals (Fahlbusch et al., 1983). But unfortunately micro-mammals dominated Ertemte fauna share so few counterpart taxa with large mammal dominated Tuchengzi fauna that it is not yet possible to correlate precisely the biochronological status between them.

To conclude, five species of Cervidae were identified from the fossil specimens collected during the excavations from 2013 to 2016: *Eostyloceros blainvillei*, *E. triangularis*, *Euprox* sp., *Cervavitus huadeensis* and *C. shanxius*. Among them *E. blainvillei*, *E. triangularis* and *Euprox* sp. are reported from Huade area for the first time, and the dentitions of *C. huadeensis* and *C. shanxius* are also reported from Huade for the first time. *E. blainvillei*, *E. triangularis* and *C. shanxius* are typical members of fauna in Yushe Zone I (Teilhard de Chardin and Trassaert, 1937), or Mahui Formation (Qiu et al., 1987) in stratigraphic term, or Baodean (Li et al., 1984; Tong et al., 1995; Qiu et al., 2006; Deng, 2006; Zhang, 2006) in biochronological term. *Euprox* existed mostly in the Late Miocene. The geological age of the mammal fossils from Tuchengzi locality is therefore of Late Miocene. As in Yushe Basin and other areas, the abundance of *C. shanxius* specimens implies forested environment in Huade area during the Late Miocene.

## 内蒙古化德土城子地点晚中新世鹿科化石新材料

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**摘要:**继1959年中苏古生物联合考察队在内蒙古化德地区发掘采集到大量晚中新世哺乳动物化石后, 笔者的课题组于2013~2016年间在化德的土城子地点发掘采集到不少哺乳动物化石。经过修理和研究, 鉴定出鹿科化石的5个种类: 布氏始柱角鹿(*Eostylloceros blainvillei*)、三角始柱角鹿(*E. triangularis*)、真角鹿未定种(*Euprox* sp.)、化德祖鹿(*Cervavitus huadeensis*)和山西祖鹿(*C. shanxius*)。其中前3个种类是在化德地区首次发现, 而后两个种的牙齿材料也是在土城子地点首次记述。布氏始柱角鹿是一种较大的鹿类, 以其鹿角具一个粗长而内弯的主枝及一个直接从角环上伸出的较长的眉枝为特征, 以前主要发现于山西的榆社盆地, 在青海柴达木盆地也找到过, 而化德是出现这个种类的第三个地区。三角始柱角鹿以其主枝横切面呈三角形而与布氏始柱角鹿相区别, 以前仅见于榆社盆地, 因此新发现的三角始柱角鹿将其地理分布范围扩大到内蒙古。真角鹿是从非脱换型鹿角向季节性脱换型鹿角过渡的代表, 在欧亚大陆都有分布, 化德是继通古尔和四子王旗之后在内蒙古发现这个属的第三个地区。化德祖鹿的鹿角具有4个枝, 远端两个枝剑形, 在土城子地点是第二次发现, 但目前尚未在其他地区发现过, 似乎是化德一带的地方种类。山西祖鹿以其下臼齿不具古鹿褶而与新罗斯祖鹿(*Cervavitus novorossiae*)相区别。山西祖鹿在中国北方的分布较广, 主要见于山西、陕西、甘肃和内蒙古, 而且在每个地点的化石标本较多, 指示其种群密度较大。布氏始柱角鹿、三角始柱角鹿和山西祖鹿是榆社盆地中榆社一带的主要鹿科成员, 出现在岩石地层的马会组或生物年代学的保德期。真角鹿的时代分布主要在晚中新世。因此根据土城子地点的鹿科化石判断其地质时代应为晚中新世, 而较多的山西祖鹿标本指示化德一带在晚中新世有较广的森林。

**关键词:** 内蒙古化德土城子, 晚中新世, 鹿科

## References

- Andersson J G, 1923. Essays on the Cenozoic of northern China. Mem Geol Surv China, Ser A, 3: 1–152
- Bohlin B, 1937. Eine tertiäre Säugetier-Faune aus Tsaidam. Palaeont Sin Ser C, 14(1): 1–71
- Colbert E H, 1936. Tertiary deer discovered by the American Museum Asiatic Expeditions. Am Mus Novit, 854: 1–21
- Colbert E H, 1940. Some cervid teeth from the Tung Gur Formation of Mongolia, and additional notes on the genera *Stephanocemas* and *Lagomeryx*. Am Mus Novit, 1062: 1–6
- Deng T, 2006. Chinese Neogene mammal biochronology. Vert PalAsiat, 44(2): 143–163
- Deng T, 2009. Late Cenozoic environmental changes in the Linxia Basin (Gansu, China) as indicated by cenograms of fossil

- mammals. *Vert PalAsiat*, 47(4): 282–298
- Deng T, Wang S Q, Shi Q Q et al., 2014. A new species of *Eostyloceros* (Cervidae, Artiodactyla) from the Late Miocene of the Linxia Basin in Gansu, China. *Zootaxa*, 3893: 363–381
- Dong W, 2004. The dental morphological characters and evolution of Cervidae. *Acta Anthropol Sin*, 23(supp): 286–295
- Dong W, 2011. Reconsideration of the systematics of the Early Pleistocene *Cervavitus* (Cervidae, Artiodactyla, Mammalia). *Estud Geol*, 67(2): 603–611
- Dong W, 2014. Brief report on 2009–2010's investigation on Neogene fossil localities in Huade, Nei Mongol. In: Dong W ed. *Proceedings of the Fourteenth Annual Meeting of the Chinese Society of Vertebrate Paleontology*. Beijing: China Ocean Press. 19–28
- Dong W, Hu C K, 1994. The Late Miocene Cervidae from Hounao, Yushe Basin, Shanxi. *Vert PalAsiat*, 32(3): 209–227
- Dong W, Liu J H, Pan Y R, 2003. A new *Euprox* from the Late Miocene of Yuanmou, Yunnan Province, China, with interpretation of its paleoenvironment. *Chin Sci Bull*, 48(5): 485–491
- Dong W, Cai B Q, Zhang L M et al., 2014. Preliminary report on 2013's test excavation at Tuchenzi fossil locality in Huade, Nei Mongol. In: Dong W ed. *Proceedings of the Fourteenth Annual Meeting of the Chinese Society of Vertebrate Paleontology*. Beijing: China Ocean Press. 29–36
- Dong W, Wang S L, Liu W H et al., 2016. Preliminary report on 2014–2015's excavations at Tuchenzi fossil locality in Huade, Nei Mongol. In: Dong W ed. *Proceedings of the Fifteenth Annual Meeting of the Chinese Society of Vertebrate Paleontology*. Beijing: China Ocean Press. 53–68
- Fahlbusch V, Qiu Z D, Storch G, 1983. Neogene mammalian faunas of Ertemter and Harr Obo in Nei Mongol, China. *Sci Sin, Ser B*, 26(2): 205–224
- Hou S K, 2015. A new species of *Euprox* (Cervidae, Artiodactyla) from the Upper Miocene of the Linxia Basin, Gansu Province, China, with interpretation of its paleoenvironment. *Zootaxa*, 3911: 43–62
- Khomenko J, 1913. La faune méotique du Village Taraklia du district de Bendery. *Ann Géol Minéral Rus*, 15: 107–143
- Li C K, Wu W Y, Qiu Z D, 1984. Chinese Neogene: subdivision and correlation. *Vert PalAsiat*, 22(3): 163–178
- Lin Y P, Pan Y R, Lu Q W, 1978. The mammalian fauna of Early Pleistocene from Yuanmou, Yunnan. In: IVPP ed. *Proceedings of Paleoanthropology*. Beijing: Science Press. 101–125
- Liu S Z, Dong W, Wang Y et al., 2017. New materials of *Cervus (Sika) magnus* from Luotuoshan Locality of Dalian, Liaoning Province. *Quaternary Sci*, 37(4): 838–844
- Petronio C, Krakhmalnaya T, Bellucci L et al., 2007. Remarks on some Eurasian pliocervines: characteristics, evolution, and relationships with the tribe Cervini. *Geobios*, 40: 113–130
- Qiu Z D, 1979. Some mammalian fossils from the Pliocene of Inner Mongolia and Gansu (Kansu). *Vert PalAsiat*, 17(3): 222–235
- Qiu Z D, Wang X M, Li Q, 2006. Faunal succession and biochronology of the Miocene through Pliocene in Nei Mongol (Inner Mongolia). *Vert PalAsiat*, 44(2): 164–181
- Qiu Z X, Huang W L, Guo Z H, 1987. The Chinese hipparionine fossils. *Palaeont Sin, New Ser C*, 25: 1–250
- Stehlin H G, 1928. Bemerkungen über die Hirsche von Steinheim am Aalbuch. *Eclogae Geol Helv*, 21: 245–256
- Teilhard de Chardin P, Trassaert M, 1937. Pliocene Camelidae, Giraffidae and Cervidae of S. E. Shansi. *Palaeont Sin, New*

Ser C, 1: 1–56

- Thenius E, 1948. Zur Kenntnis der fossilen Hirsche des Wiener Beckens, unter besonderer Berücksichtigung ihrer stratigraphischen Bedeutung. *Ann Naturhist Mus Wein*, 56: 262–307
- Tong Y S, Zheng S H, Qiu Z D, 1995. Cenozoic mammal ages of China. *Vert PalAsiat*, 33(4): 290–314
- Viret J, 1961. Artiodactyla. In: Piveteau J ed. *Traité de Paléontologie VI*, Vol. 1. Paris: Masson et Cie. 1038–1084
- Vislobokova I A, 1990. The Fossil Deer of Eurasia. Moscow: Sciences Press. 1–208
- Vislobokova I A, 2007. New data on Late Miocene mammals of Kohfidisch, Austria. *Paleont J*, 41: 451–460
- Wang B Y, Wu W Y, 1979. The Artiodactyla. In: IVPP ed. *Vertebrate Fossils of China*. Beijing: Science Press. 501–620
- Wang L H, Zhang Z Q, 2011. A new species of *Euprox* (Cervidae, Mammalia) from the Middle Miocene of Damiao, Nei Mongol, China. *Vert PalAsiat*, 49(4): 365–376
- Wang L H, Zhang Z Q, 2014. Late Miocene *Cervavitus novorossiae* (Cervidae, Artiodactyla) from Lantian, Shaanxi Province. *Vert PalAsiat*, 52(3): 303–315
- Zdansky O, 1925. Fossile Hirsche Chinas. *Palaeont Sin*, Ser C, 2(3): 1–94
- Zdansky O, 1927. Weitere Bemerkungen über fossile Cerviden aus China. *Palaeont Sin*, Ser C, 4(4): 1–30
- Zhai R J, 1963. Additional note on *Sinohippus zitteli*. *Vert PalAsiat*, 7(2): 168–172
- Zhang Z Q, 2006. Chinese Late Neogene land mammal community and the environmental changes of East Asia. *Vert PalAsiat*, 44(2): 133–142
- Zhang Z Q, Gentry A W, Kaakinen A et al., 2002. Land mammal faunal sequence of the Late Miocene of China: new evidence from Lantian, Shaanxi Province. *Vert PalAsiat*, 40(3): 165–176